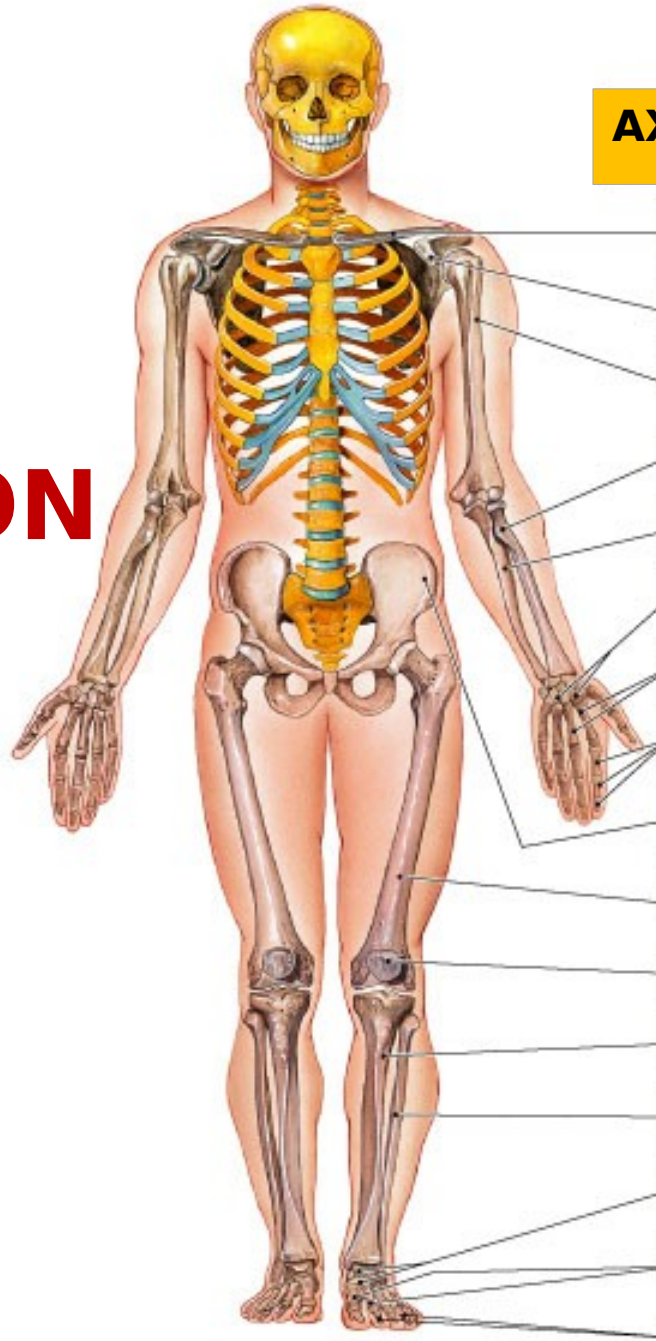
The BONES

The BONES of the SKELETON



- **SKELETAL SYSTEM** 206
  - **AXIAL SKELETON** 80
  - **APPENDICULAR SKELETON** 126
    - Pectoral girdle 4
      - Clavicle 2
      - Scapula 2
    - Upper limbs 60
      - Humerus 2
      - Radius 2
      - Ulna 2
      - Carpal bones 16
      - Metacarpal bones 10
      - Phalanges (proximal, middle, distal) 28
    - Pelvic girdle 2
      - Hip bone (os coxae) 2
    - Lower limbss 60
      - Femur 2
      - Patella 2
      - Tibia 2
      - Fibula 2
      - Tarsal bones 14
      - Metatarsal bones 10
      - Phalanges 28

Functions of Bone (Osseous Tissue)

- Structural Support:
- Protection:
- Storage: **1)** minerals and **2)** lipids
- Blood Cell Production:
- Body Movement:
- Detoxification:

Classification of Bone by Shape

There are **6** categories

a) Long –

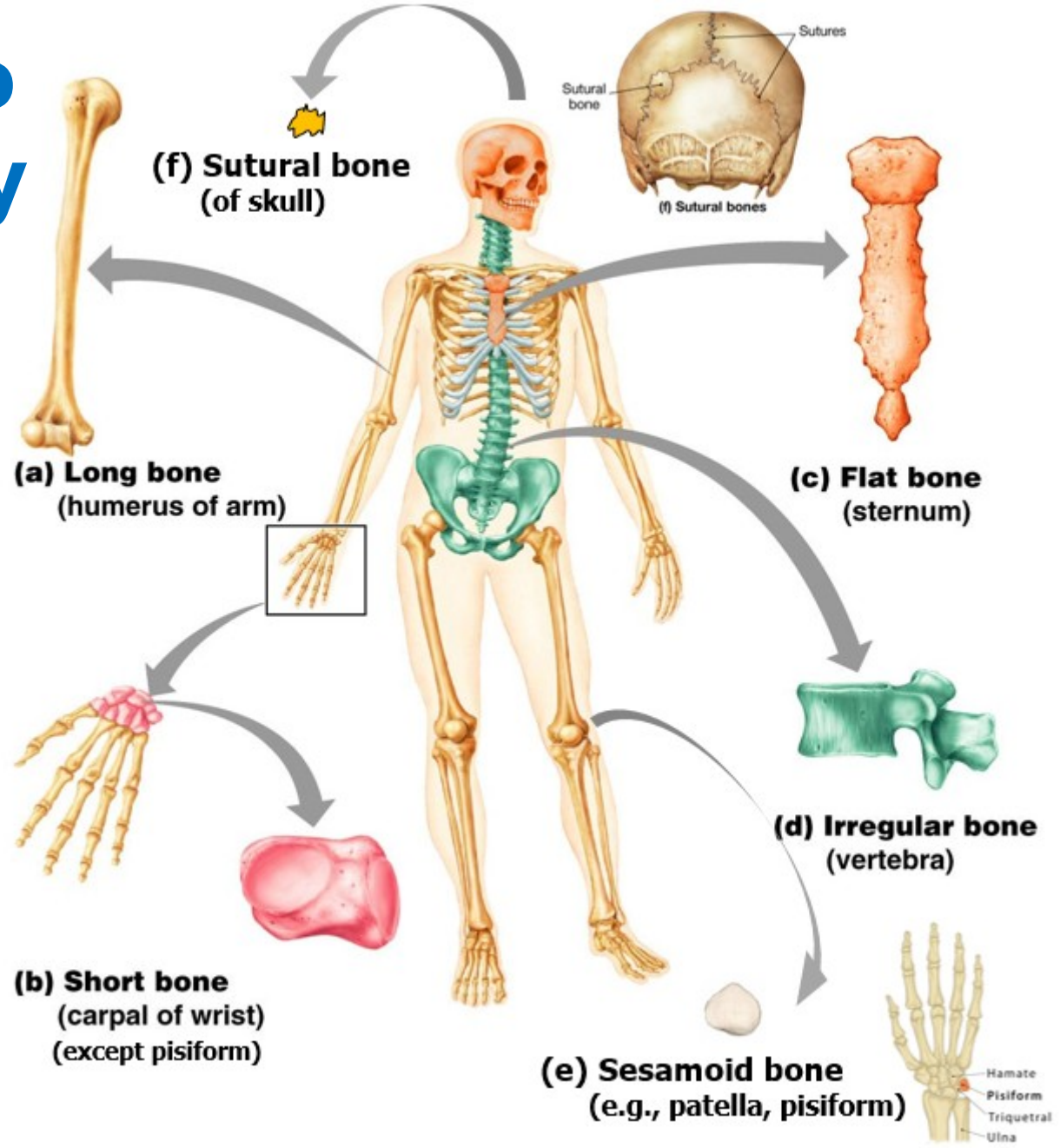
b) Short –

c) Flat –

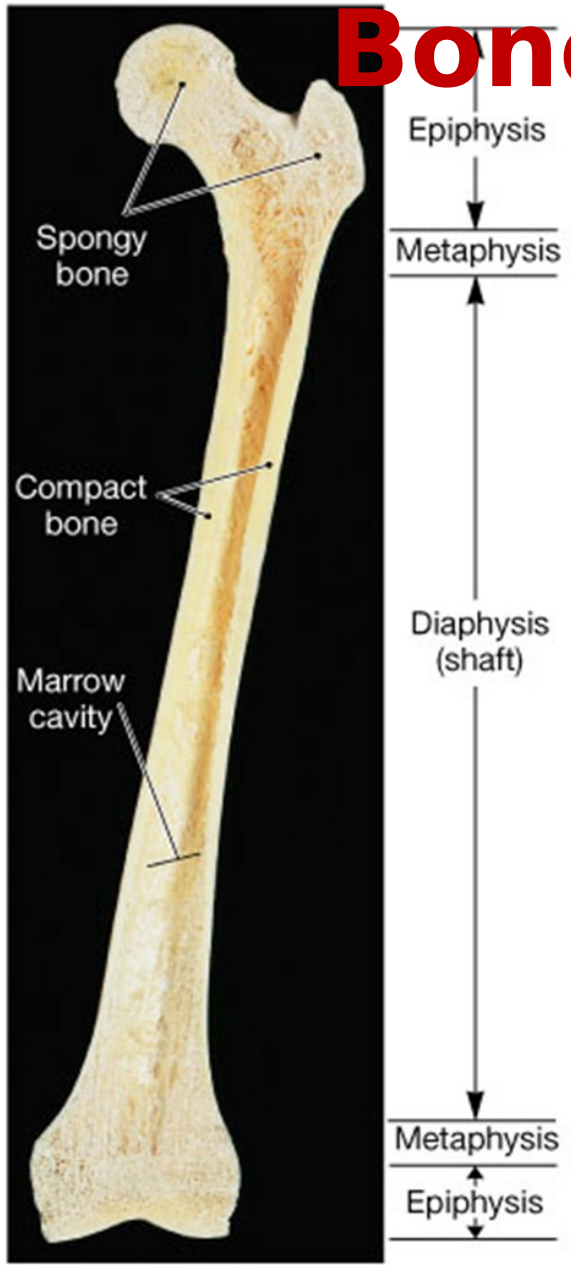
d) Irregular –

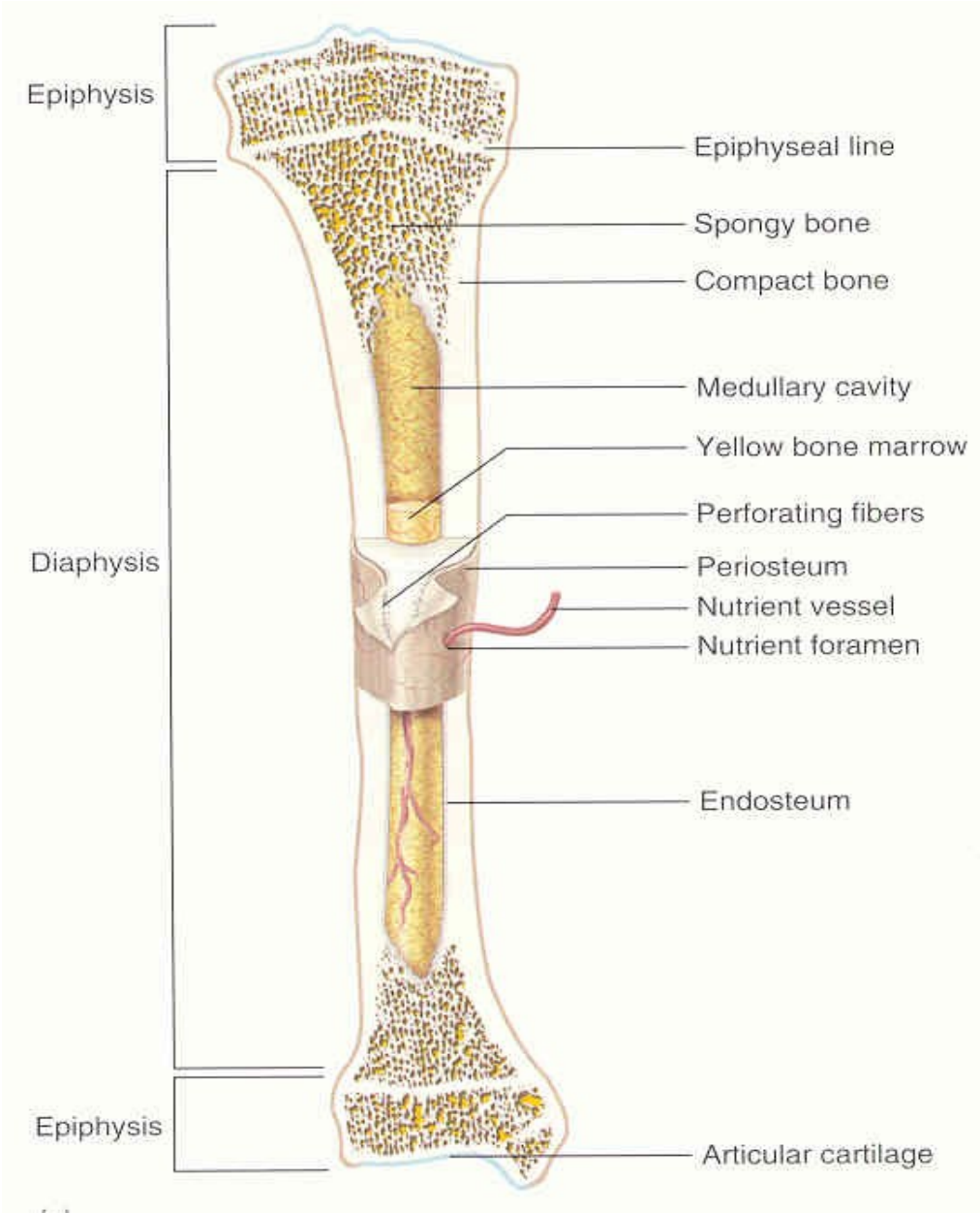
e) Sesamoid –

f) Sutural –

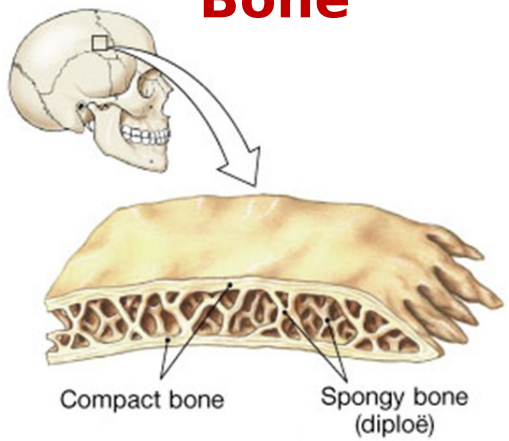


Anatomy of a Long Bone





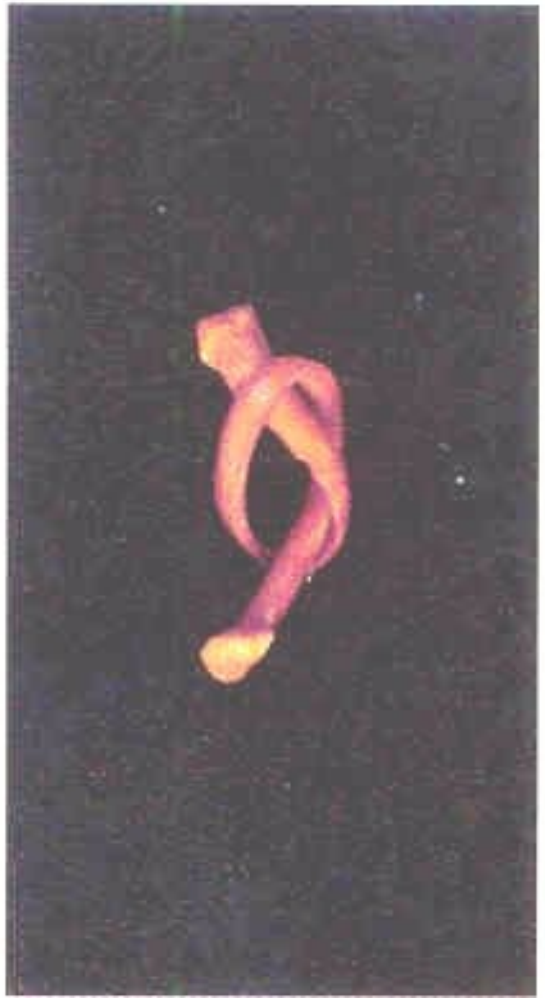
Anatomy of a Flat Bone



Constituents of Bone

Organic (~1/3)	Inorganic (~2/3)
Collagen (and some other proteins)	80% Calcium Hydroxyapatite $Ca_3(PO_4)_2 \cdot (OH)_2$
Specialized Bone Cells (4)	15% Calcium Carbonate $CaCO_3$
Glycosaminoglycans (GAGs)	5% Other Minerals: Mg, SO_4, Na, K
Gives Bone Flexibility!	**Gives Bone Rigidity!**

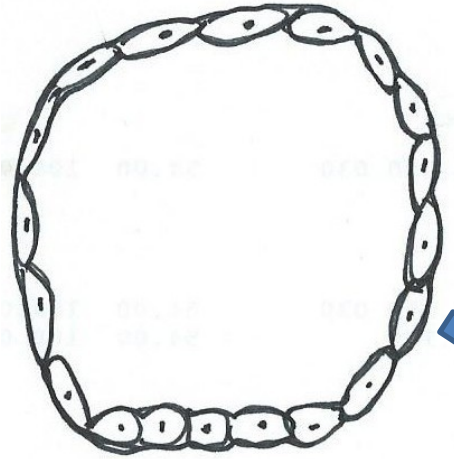
...e soaked in acetic acid to de-mineralize it...



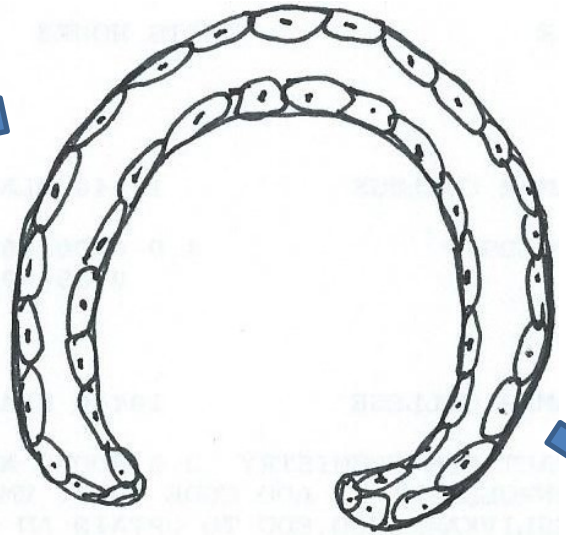
Heating bone
destroys proteins in it...

Makes it very brittle

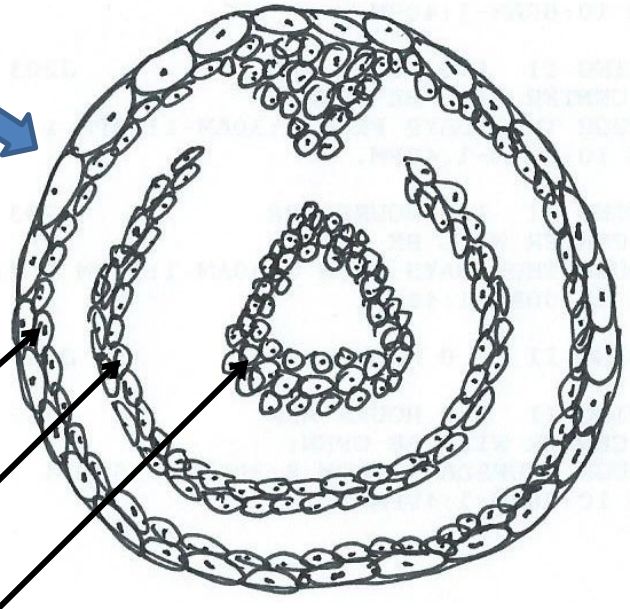
The 3 Primary Germ Layers of the Embryo (Yolk Sac)



Blastula



Gastrula



Embryo

Ectoderm

Mesoderm

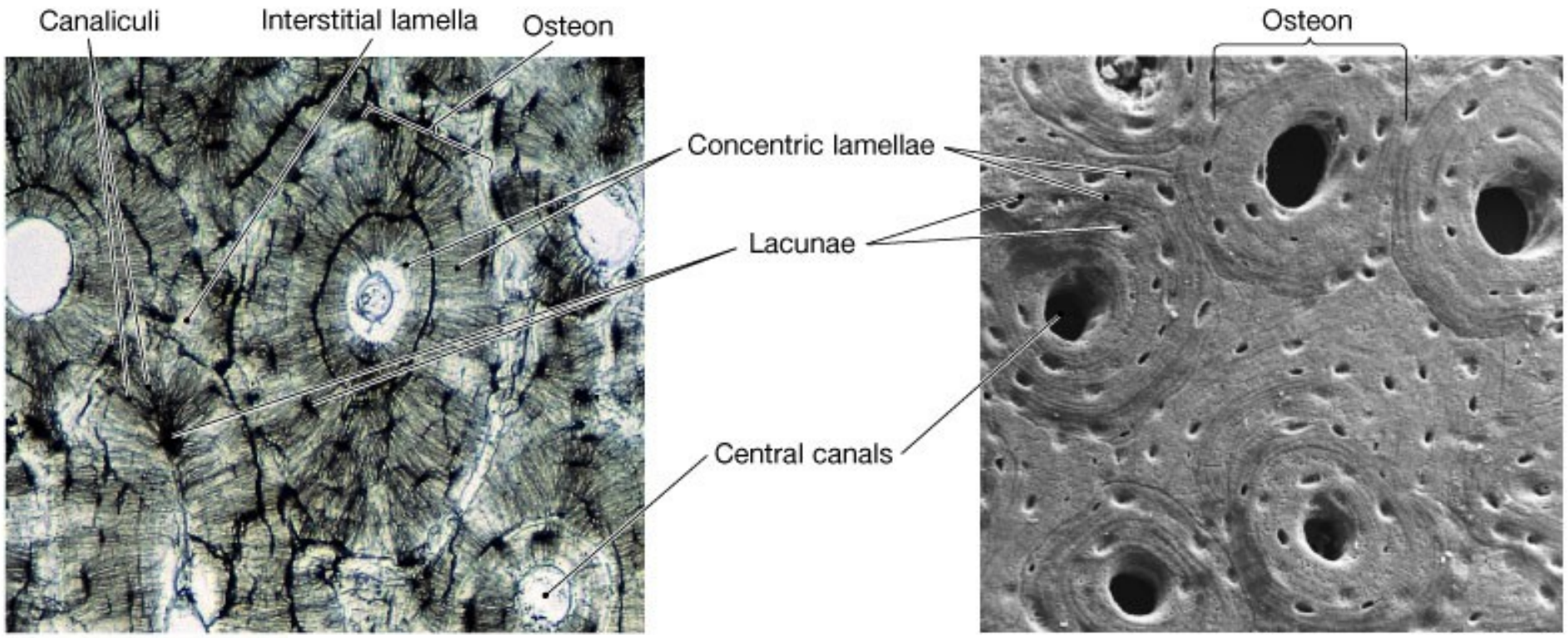
Endoderm

The Three Primary Germ Layers

The three **primary (1°) germ layers** differentiate into the cells of each of the four (4) **primary tissues** of the body.

Endoderm	Mesoderm	Ectoderm
Epithelium of Respiratory tract (pharynx, larynx, trachea, bronchi, lungs). Entire G.I. tract. Lining of auditory canal, tonsils, Thyroid, parathyroid, and thymus. Urinary bladder and urethra. Liver and pancreas.	**All Connective tissue**, Embryonic, mesenchyme, connective tissue proper, cartilage, bone, and blood. **Endothelium** of blood vessels, lymphatic vessels, joint cavities, internal body cavities. Kidneys and ureters. **All Muscle tissue**, Smooth, Cardiac, and Skeletal. Adrenal cortex. Dentin of teeth. Internal reproductive organs.	**Epidermis** of skin and epidermal derivatives: such as hair, nails, glands of the skin; linings of oral, nasal, anal, and vaginal cavities. **All Nervous tissue**, Special sense organs, including eyes (and lens), inner ear, olfaction and gustation (taste), and skin sensations. Adrenal medulla. Enamel of teeth. Pituitary gland.

Compact Bone

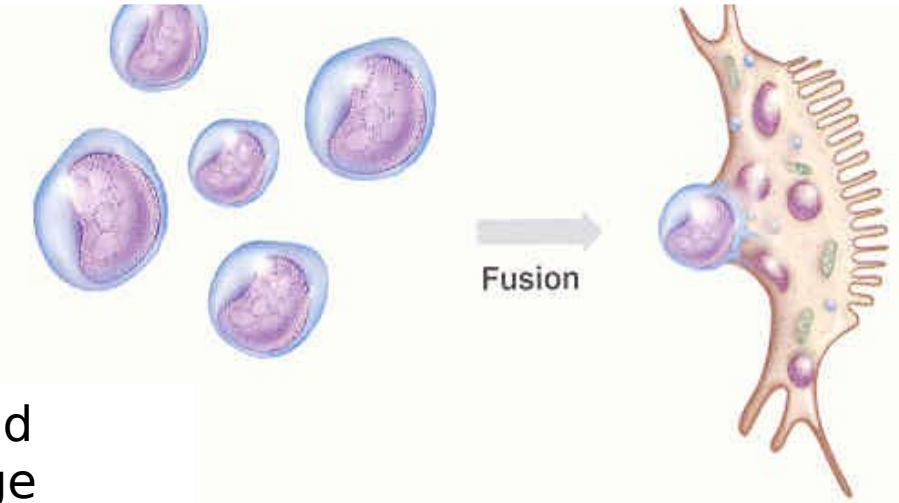


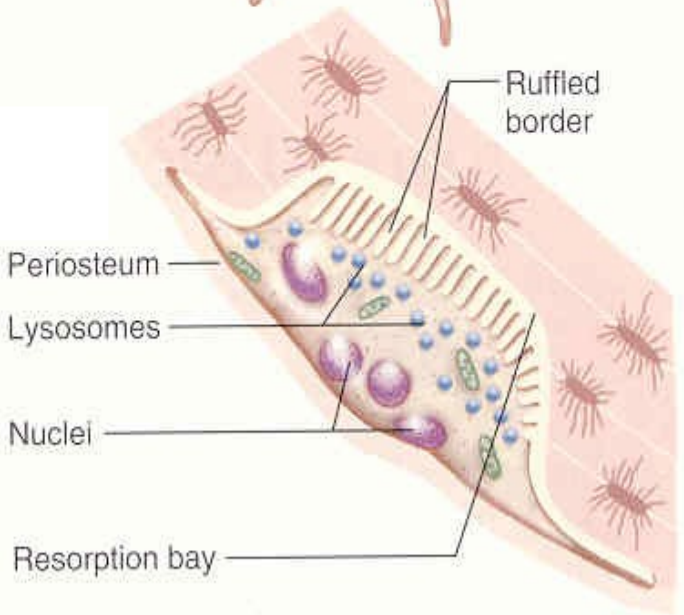
Specialized Bone Cells

Osteoprogenitor cells Osteoblasts Osteocytes

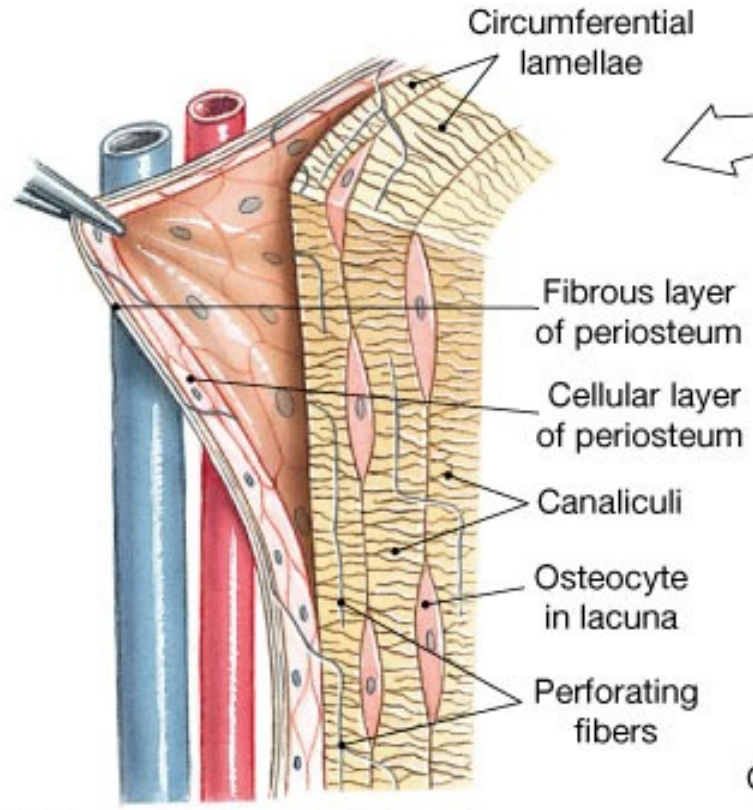
Osseo
Lineage

Stem cells
Osteoclasts

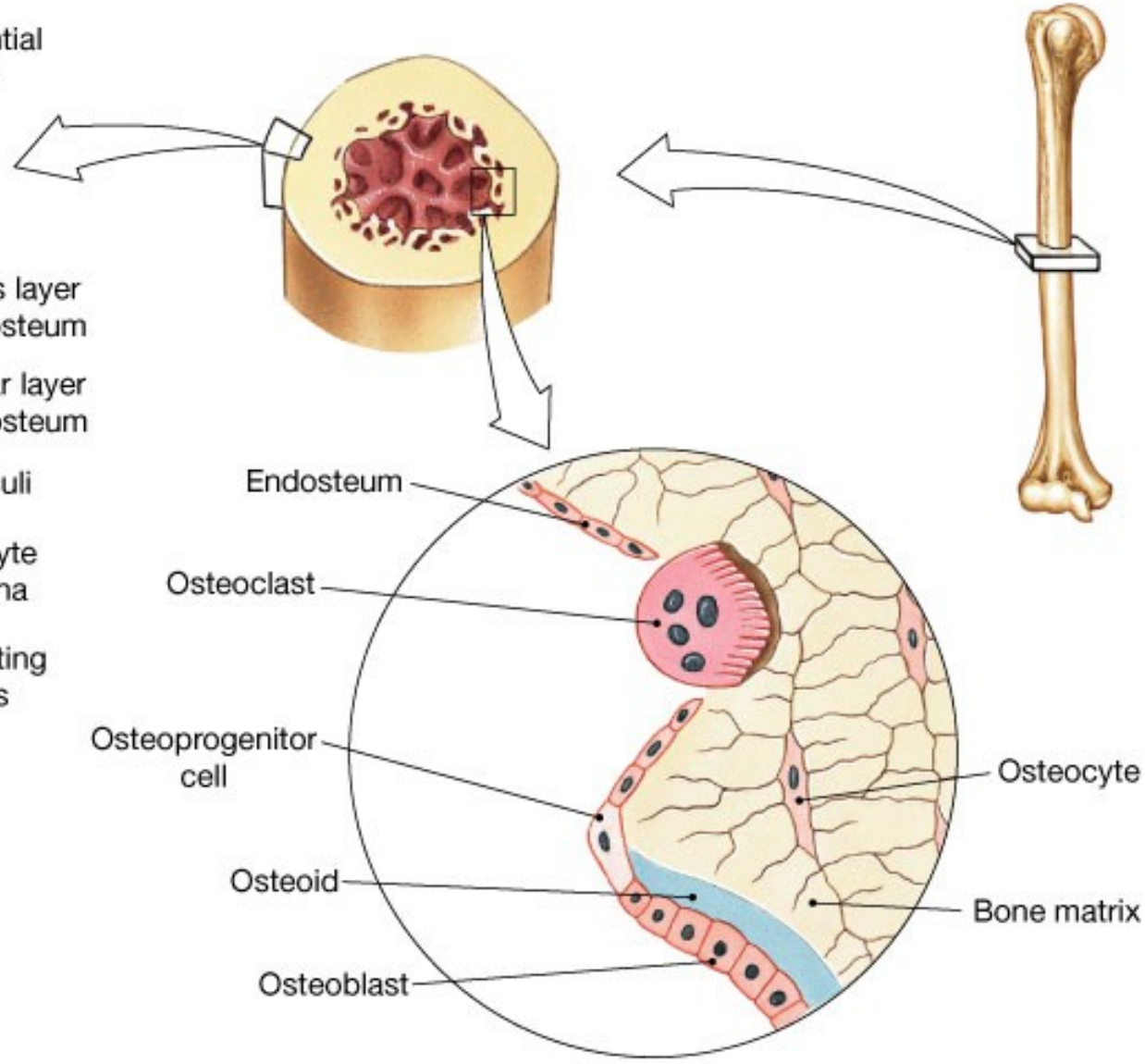




Myeloid
Lineage



(a) The periosteum contains outer (fibrous) and inner (cellular) layers. Collagen fibers of the periosteum are continuous with those of the bone, adjacent joint capsules, and attached tendons and ligaments.



(b) The endosteum is an incomplete cellular layer containing epithelial cells, osteoblasts, osteoprogenitor cells, and osteoclasts.

Hormonal Control of Bone Tissue

Human Growth Hormone (hGH): (**Pituitary gland**)

Thyroxine: (**Thyroid gland**)

Sex Hormones: (**Ovaries and Testes**)
(estrogen, progesterone, testosterone)

Stimulate Osteoblasts

Calcitonin: (**Thyroid gland**) → Inhibits Osteoclasts

Parathyroid Hormone: (**Parathyroid gland**) → Stimulates Osteoclasts

Calcitriol: (**Skin to kidneys**) → Increases Ca^{2+} absorption from intestine,
Decreases Ca^{2+} loss in urine.

2 Types of Ossification

1. Intramembranous Ossification

Mesoderm

↓

Mesenchymal cells

↓

Osteoprogenitor cells

↓

Osteoblast

↓

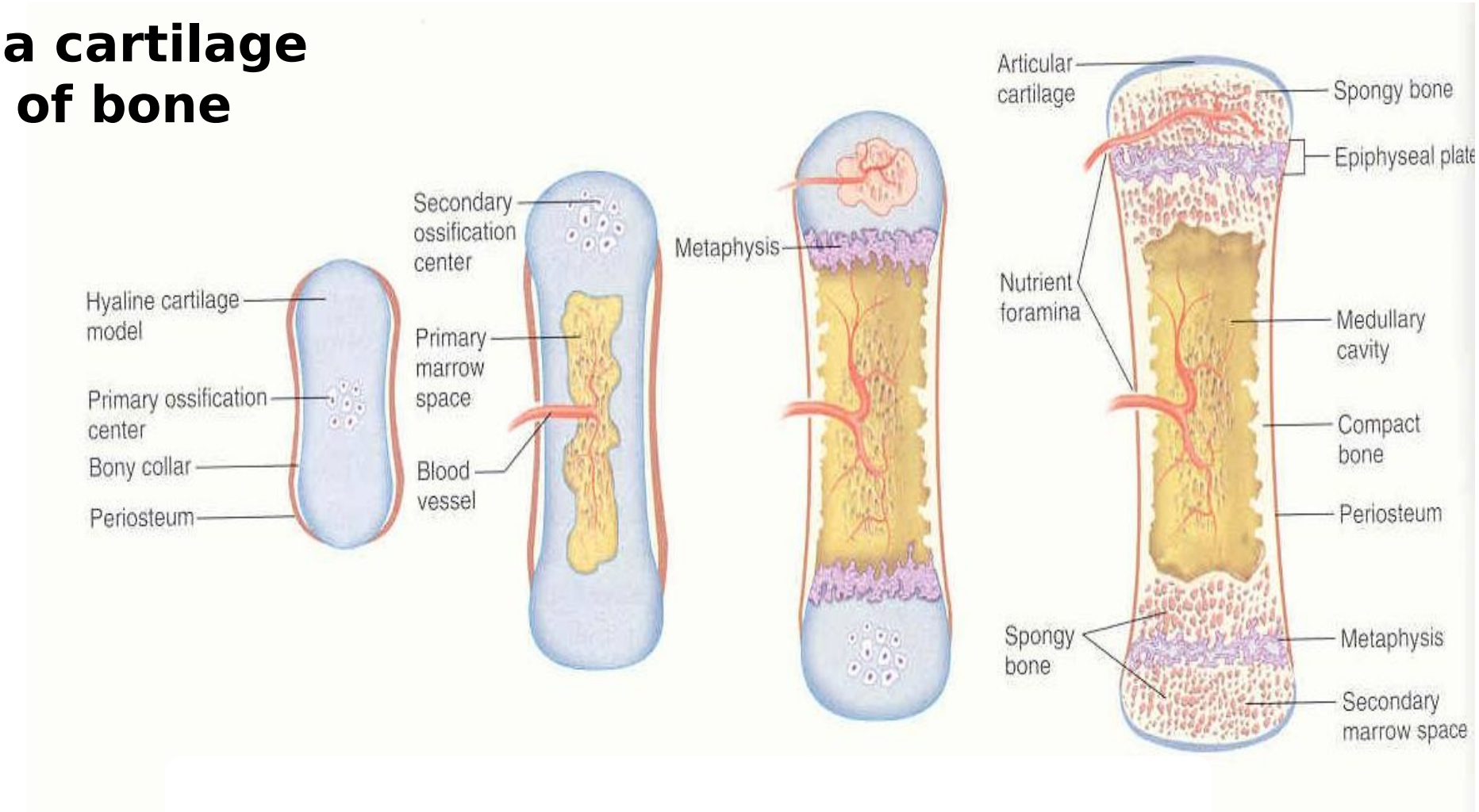
Osteocytes in bone tissue

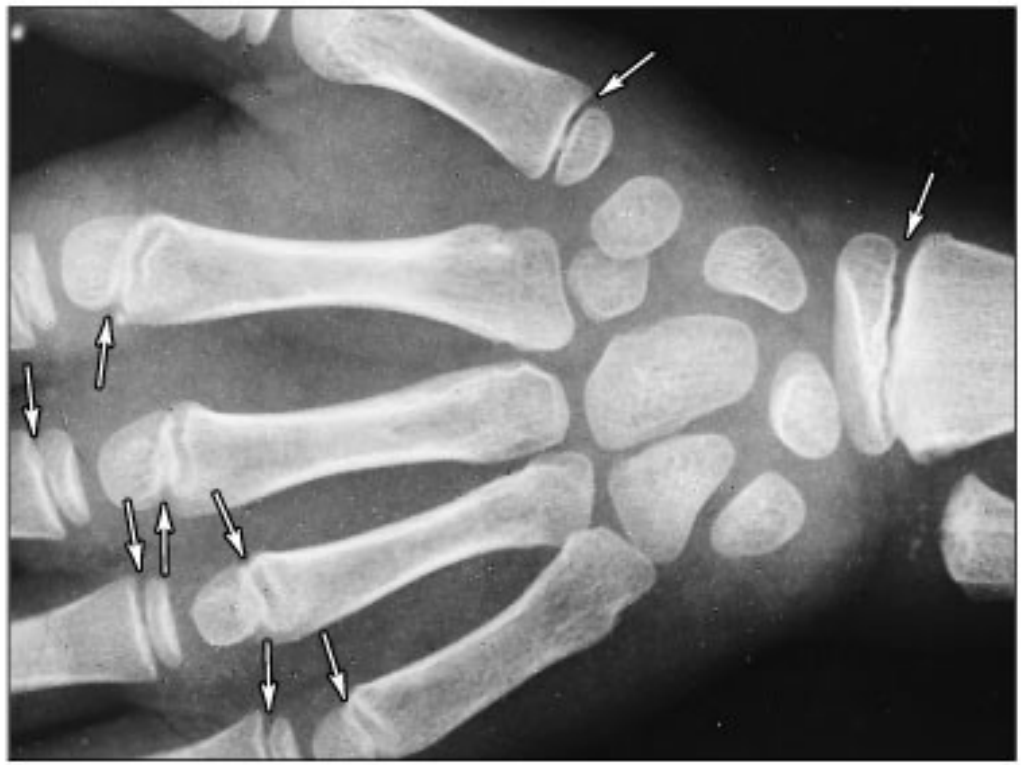
2. Endochondral ossification - most bones formed this way

- Bone replaces a cartilage model of bone .
- Blood vessels migrate into center cartilage bone (cavities left by dying chondrocytes).
- **Mesenchymal** cells brought with the blood and differentiate into **Osteoblasts**.
- Osteoblasts replace cartilage with spongy bone => becomes **primary ossification center**.
- Creates spongy bone in shaft remodeled (osteoclasts) into a **marrow cavity**, outer compact bone.
- Then, **secondary ossification center** begins at each **epiphysis** of bone. This leaves a **cartilage band** at **metaphysis** - called the **epiphyseal plate** (growth plate).
- Length-wise growth of long bones occurs at **epiphyseal plate as** chondrocytes

2. ENDOCHONRAL OSSIFICATION

Starts as a cartilage model of bone

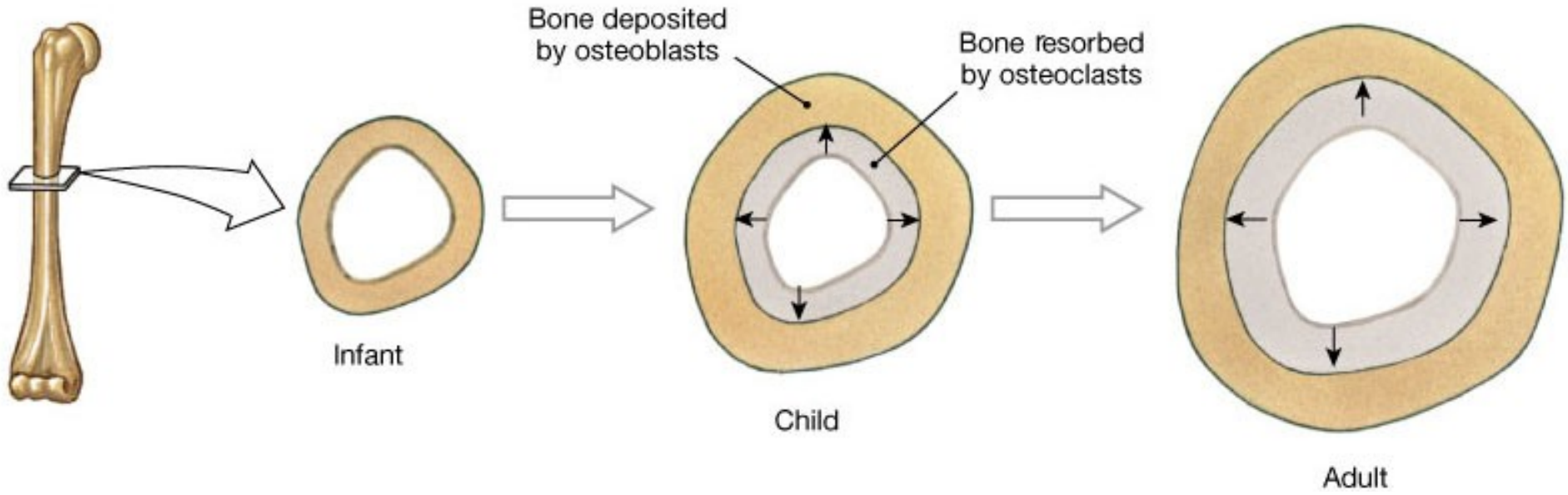




(a) Epiphyseal cartilages

(b) Epiphyseal lines

Appositional Bone Growth

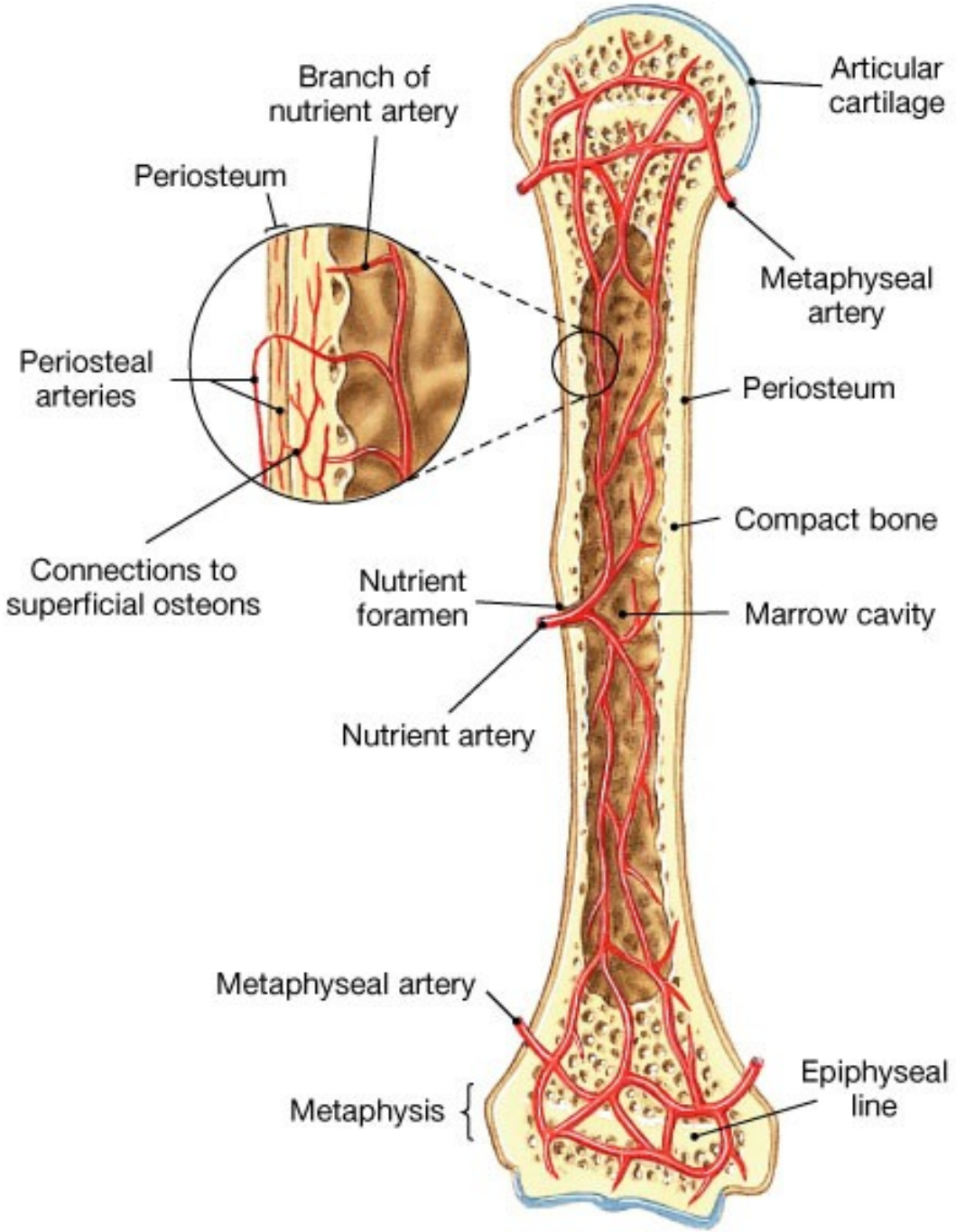


Bones can increase in **thickness** after length-wise growth stops = **Appositional Bone Growth**.

Process by which old bone lining medullary cavity is **reabsorbed** and new bone produced beneath the periosteum, increasing the bone **diameter**.

Bone Remodeling: Depositing and removing bone tissue!

Notice all of the features and terms used for the elements of a bone in the body



Bone Fractures

Simple (Closed): Skin remains intact.

Compound (Open): Skin is broken exposing the bone and deep tissues to the exterior.

Compound Fractures have:

- Risk of infection.
- Greater risk of blood loss if fracture lacerates blood vessels.

A **Pott's fracture** occurs at the ankle and affects both bones of the leg.

Comminuted fractures, such as this fracture of the femur, shatter the affected area into a multitude of bony fragments.

Transverse fractures, such as this fracture of the ulna, break a shaft bone across its long axis.

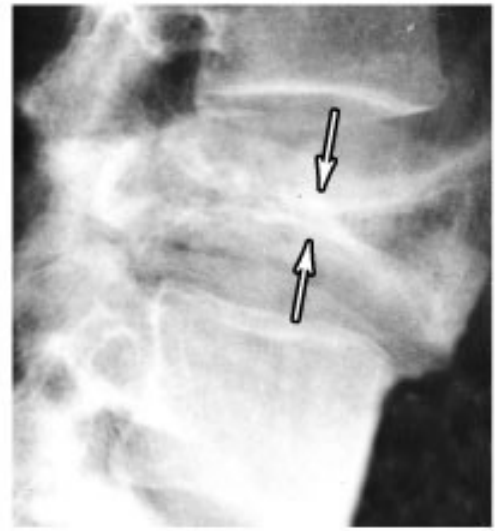
Spiral fractures, such as this fracture of the tibia, are produced by twisting stresses that spread along the length of the bone.

Displaced fractures produce new and abnormal bone arrangements; **nondisplaced fractures** retain the normal alignment of the bones or fragments.

A **Colles' fracture**, a break in the distal portion of the radius, is typically the result of reaching out to cushion a fall.

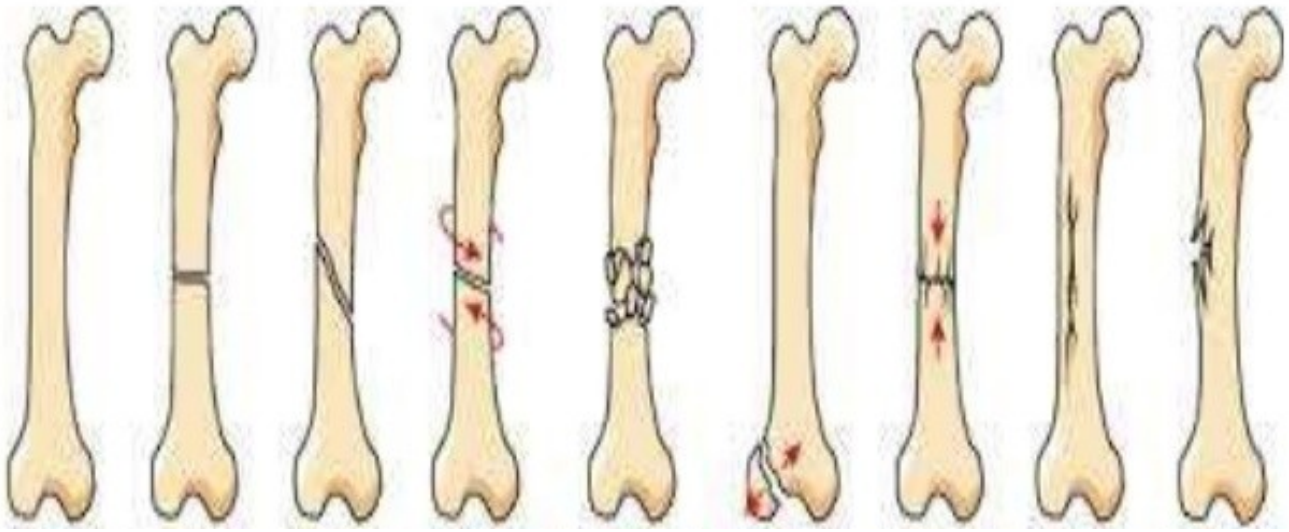
In a **greenstick fracture**, such as this fracture of the radius, only one side of the shaft is broken, and the other is bent. This type of fracture generally occurs in children, whose long bones have yet to ossify fully.

Epiphyseal fractures, such as this fracture of the femur, tend to occur where the bone matrix is undergoing calcification and chondrocytes are dying. A clean transverse fracture along this line generally heals well. Unless carefully treated, fractures between the epiphysis and the epiphyseal cartilage can permanently stop growth at this site.

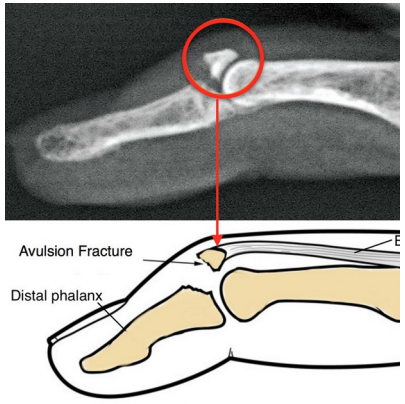


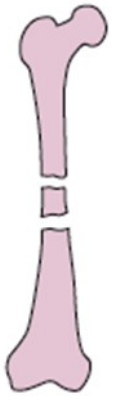
Compression fractures occur in vertebrae subjected to extreme stresses, such as those produced by the forces that arise when you land on your seat in a fall.

Review Typical Bone



Normal Transverse Oblique Spiral Comminuted Avulsion
Impacted Fissure Greenstick





Comminuted

Transverse

Greenstick

Hairline

Avulsion

Oblique

Spiral

Segmental

Compression

Impacted

Longitudinal

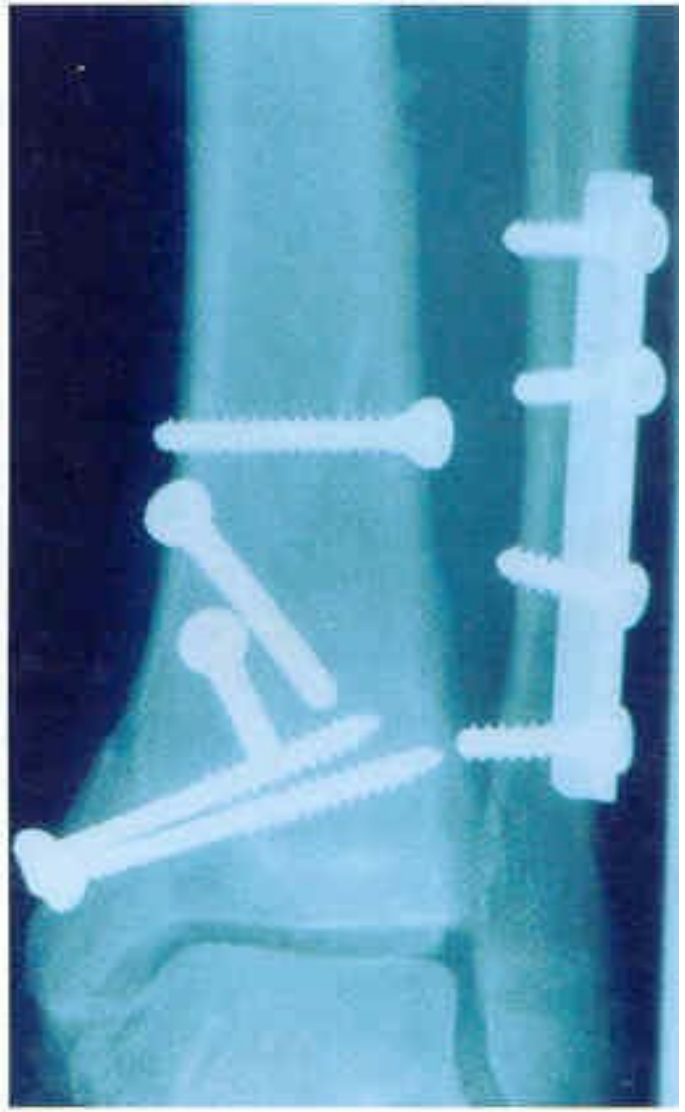
Stress

Torus (Buckle)

Colle’s

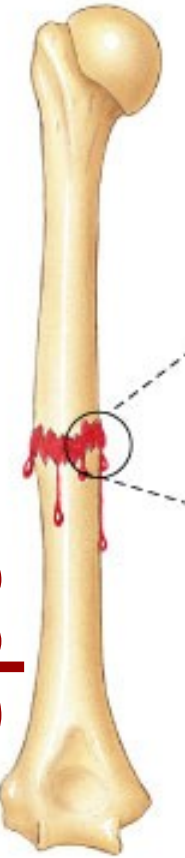
Pott’s

Fissure

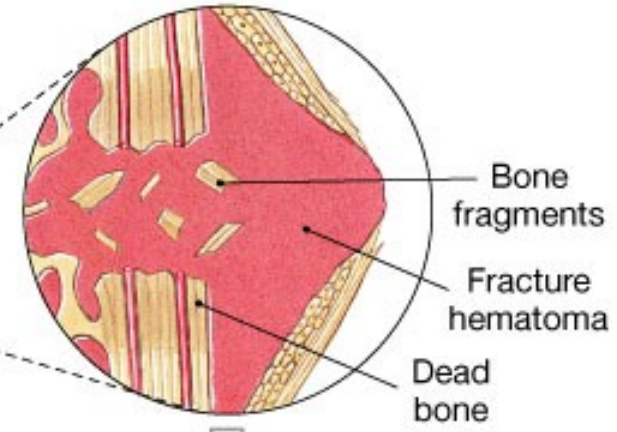


L5

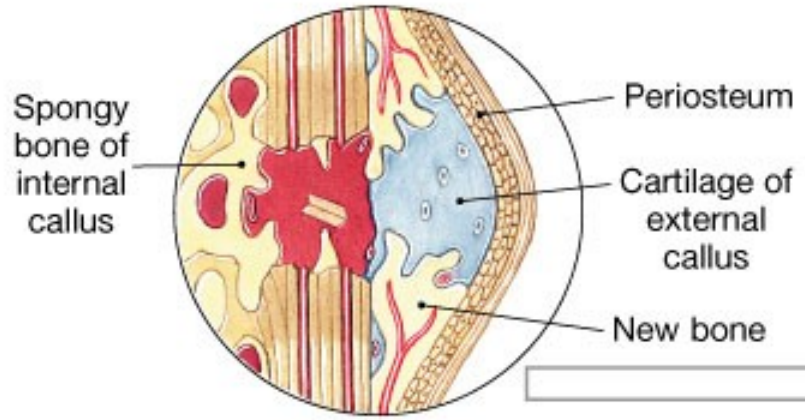
Bone Repair



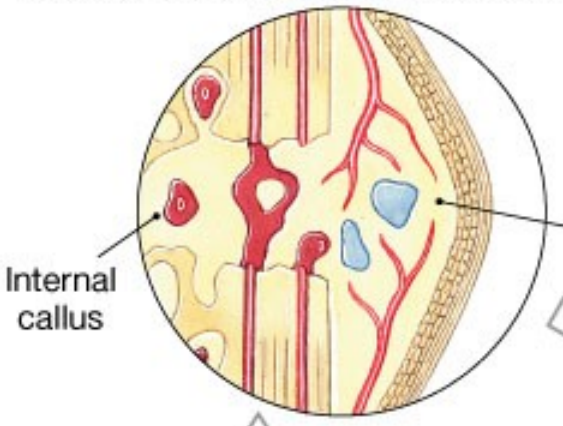
STEP 1:
Immediately after the fracture, extensive bleeding occurs. Over a period of several hours,a large blood clot, or fracture hematoma, develops.

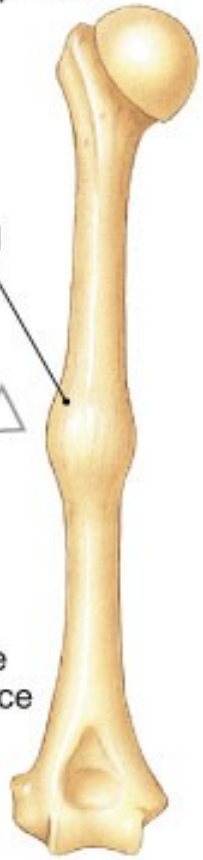


STEP 2:
An internal callus forms as a network of spongy bone unites the inner surfaces, and an external callus of cartilage and bone stabilizes the outer edges.



STEP 3:
The cartilage of the external callus has been replaced by bone, and struts of spongy bone now unite the broken ends. Fragments of dead bone and the areas of bone closest to the break have been removed and replaced.

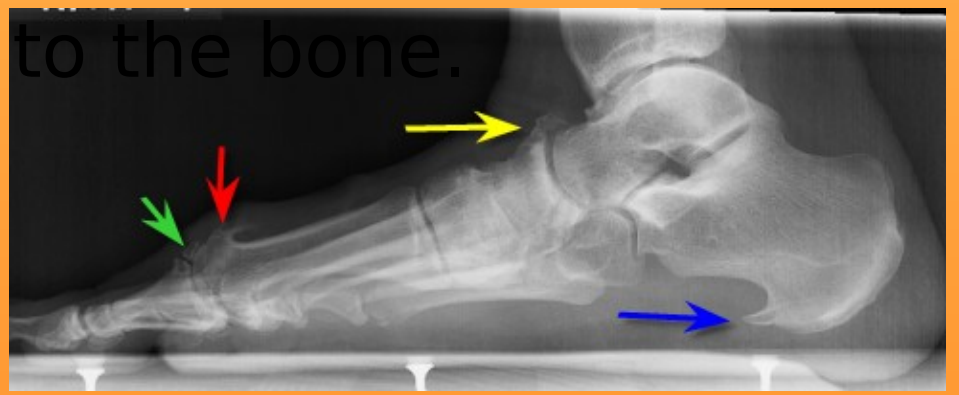




STEP 4:
A swelling initially marks the location of the fracture. Over time, this region will be remodeled, and little evidence of the fracture will remain.

Disorders of Bone Tissue

- **Osteopenia**: A reduction in bone mass with age.
- **Osteomalacia** (called ‘Rickets’ in children): Defective mineralization of bone, resulting in too much flexibility, bone cannot bear weight sufficiently.
- **Osteophyte:** also called a **bone spur**, is an outgrowth of bone occurring along the edges of a bone. Can form in any bone but most commonly found in joints and where ligaments or tendons attach to the bone.



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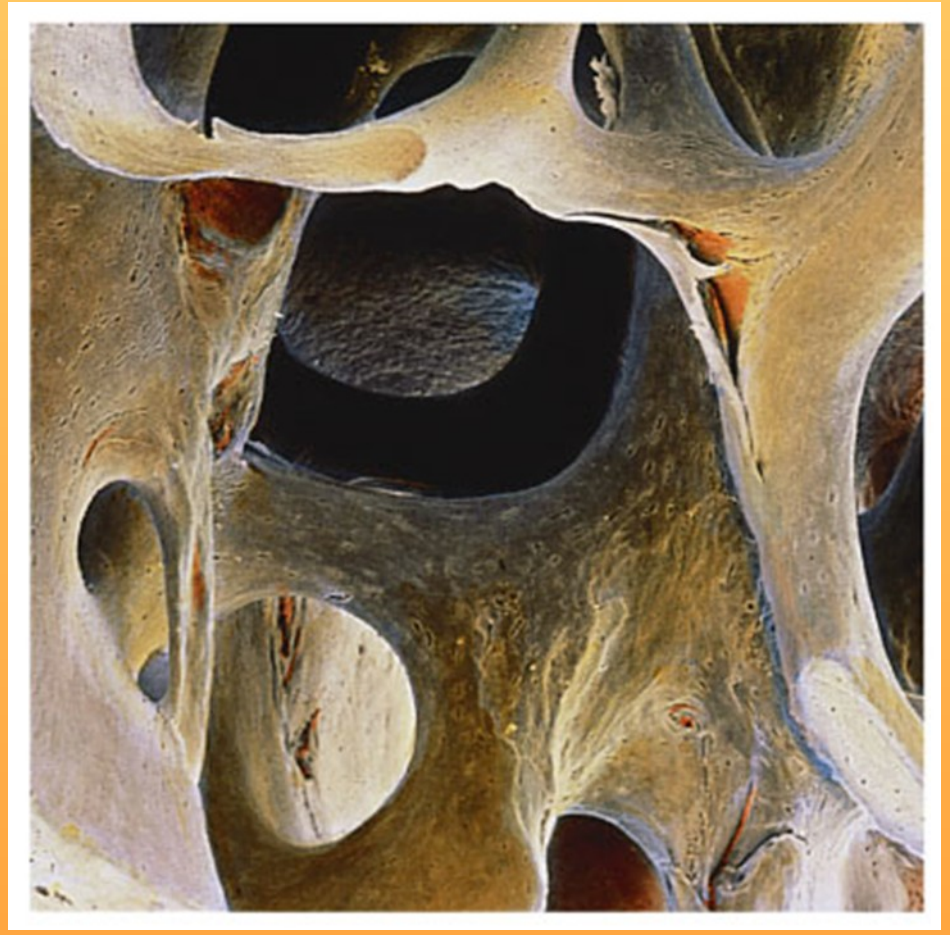
- **Osteoporosis**: A significant reduction in bone mass that impairs function.

Too little mineralization of bones can be caused by:

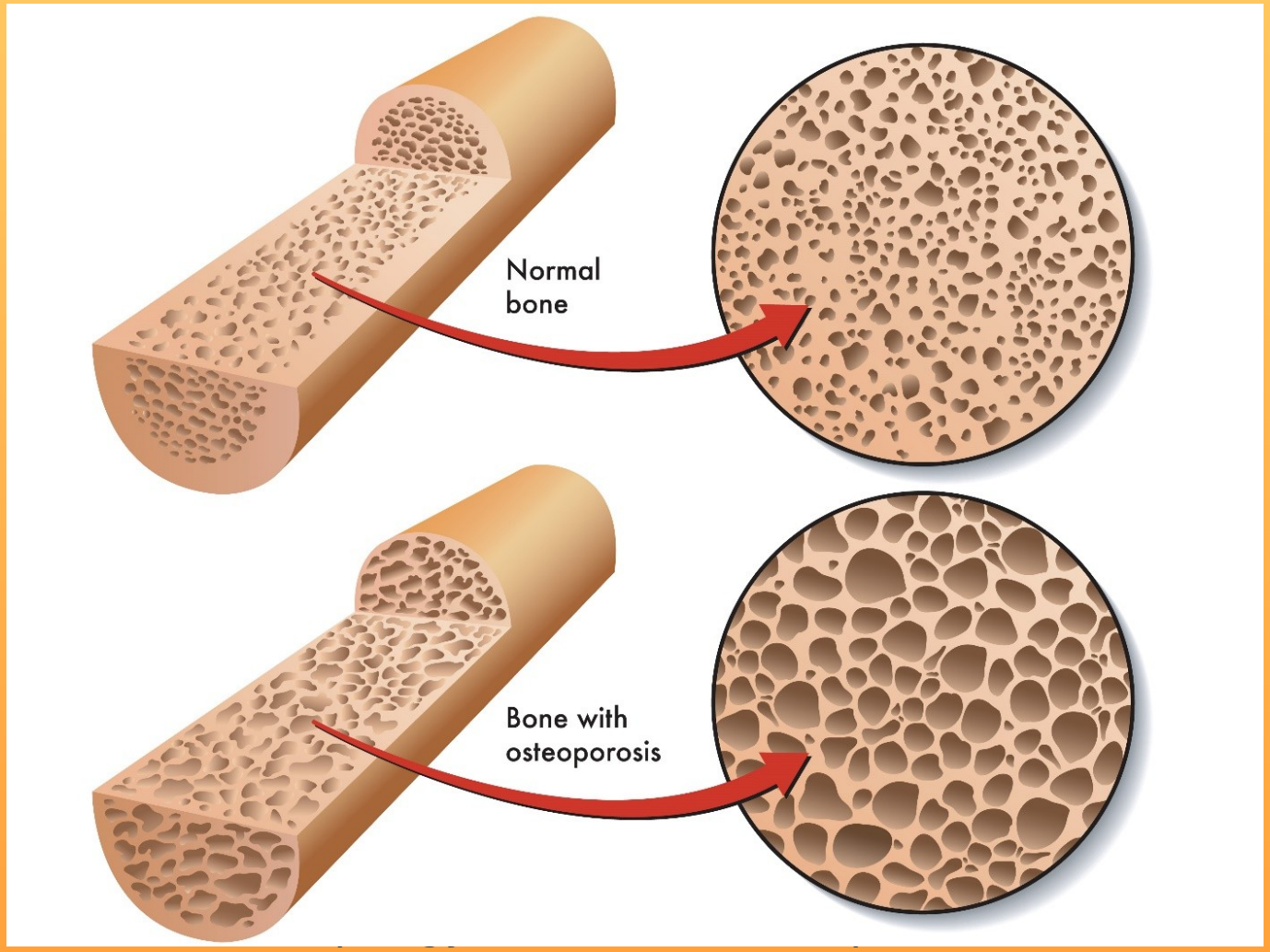
1) Decrease in hormone levels (less mass of bones).
2) Deficiency of minerals in youth, thus too little bone mass to begin with.

3) Imbalance of osteoblasts and osteoclasts activity that impairs normal bone mass.

Osteoporosis:



Normal Spongy Bone (SEM x 25)



(SEM x 21)

The 4 Essential things required for Normal Bone Growth, Repair and Remodeling …

1) Adequate Minerals:
Plenty of Ca^{2+} and PO_4^{2-}. Also extremely important are the trace minerals (~80 of them).

2) Adequate Vitamins:
Vitamin D, Vitamin K2, Vitamin C, and Vitamin A.

3) Appropriate Hormone Levels:
Human Growth Hormone (hGH), Thyroxine, Calcitriol, Parathyroid Hormone, Calcitonin, and Sex Hormones.

4) Weight Bearing Exercise:
Bone is very dynamic tissue, responds quickly to use or disuse (Atrophy and Hypertrophy).